SDLS140 – Wave propagation in a semicircular canyon

Summary:

The purpose of this test is to study the transitory answer of a semicircular model 2D of canyon subjected to a movement of plane wave of vertical propagation according to the directions P (vertical direction of propagation) and S (normal horizontal direction with the propagation). The imposed movement is a sinusoidal displacement in times of pulsation 8.15 Hz.

The surface structure is with a grid in triangles and one affects on his edges inferior and side elements of absorbing border allowing to apply the loading by plane wave.

One compares for each request the maximum ones of horizontal and vertical displacement along the edge higher of the canyon than those obtained by an analytical study provided by the reference [bib1].

One uses two modelings for the loading:

- the modeling A where one applies a loading plane wave to all the absorbing borders, including on the side faces.
- modeling B where one applies to the side faces of the loads in the forms of tablecloths of forces of type plane wave and nodal force exits of results of a calculation to an auxiliary model of column of unit ground thickness by the operator DEFI_SOL_EQUI.

The comparison on the space paces and amplitudes along the higher edge is rather satisfactory for two modelings compared to the reference.
1 Description

1.1 Geometry

The model of study is a semicircular canyon of ray \( R_0 = 100 \text{m} \), prolonged horizontally on both sides of same dimension and of vertical depth \( H = 200 \text{m} \) (cf Figure 1.1).

![Figure 1.1: geometry and dimensions of the canyon](image)

1.2 Properties of materials

The properties of the ground for the structure of the canyon are given in the following table.

<table>
<thead>
<tr>
<th>Material</th>
<th>Ground</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young modulus</td>
<td>( 1.885 \times 10^{10} \text{ Pa} )</td>
</tr>
<tr>
<td>Poisson's ratio</td>
<td>0.33</td>
</tr>
<tr>
<td>Density</td>
<td>( 2650 \text{ kg/m}^3 )</td>
</tr>
</tbody>
</table>

1.3 Boundary conditions and loadings

1.3.1 Boundary conditions

The lateral sides and inferior do not have blocking but present a condition of border absorbing by the assignment of linear elements absorbents.

1.3.2 Loading:

The loading consists in applying one imposed movement of plane wave in the form of sinusoidal displacement in times of pulsation \( 8.15 \text{ Hz} \) (cf Figure 1.3.2).
2 Reference solution

The reference solution is given by an analytical approach extracted from the reference [bib1] and represented on the figure below respectively like amplitudes of the answers to a wave P and a sinusoidal wave S of frequencies 8.15 Hz along the higher edge of the canyon according to the horizontal X-coordinate (cf Figure 2).

3 Modeling A

3.1 Characteristics of modeling

The structure is modelled by 1496 surface meshes of type TRIA3 modelled in D_PLAN, like by 80 meshes of edge of the type SEG2 modelled in D_PLAN_ABSO (cf Figure 3.1)
3.2 Comparisons and results

3.2.1 Comparisons

One compares for each request the maximum ones of horizontal displacement $DX$ and vertical $DY$ along the higher edge of the canyon according to the horizontal X-coordinate, with those obtained by an analytical study provided by the reference [bib1]. The following figure (Figure 3.2.1) synthesizes the 4 answers (2 directions of request, 2 directions of answer) to compare with those of Figure 2.

3.2.2 Results tested

The results tested are of not-regression and correspond to the computed values for each direction of request S and P and according to the components $L_{DX}$ and vertical $DY$ with the nodes of
horizontal X-coordinate 0 (center of the canyon), 100 (edge of the canyon) and 200 (flat rim of the foundation).

<table>
<thead>
<tr>
<th>Node</th>
<th>Direction</th>
<th>Component</th>
<th>Absc.</th>
<th>Value (m)</th>
<th>Precision</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>N785</td>
<td>P</td>
<td>DY</td>
<td>0</td>
<td>2.4492E+0</td>
<td>1.0E−6</td>
<td>NON_REGRESSION</td>
</tr>
<tr>
<td>N408</td>
<td>P</td>
<td>DX</td>
<td>100</td>
<td>1.4916E−1</td>
<td>1.0E−6</td>
<td>NON_REGRESSION</td>
</tr>
<tr>
<td>N408</td>
<td>P</td>
<td>DY</td>
<td>100</td>
<td>2.1960E+0</td>
<td>1.0E−6</td>
<td>NON_REGRESSION</td>
</tr>
<tr>
<td>N775</td>
<td>P</td>
<td>DX</td>
<td>200</td>
<td>7.9120E−1</td>
<td>1.0E−6</td>
<td>NON_REGRESSION</td>
</tr>
<tr>
<td>N775</td>
<td>P</td>
<td>DY</td>
<td>200</td>
<td>1.3270E+0</td>
<td>1.0E−6</td>
<td>NON_REGRESSION</td>
</tr>
<tr>
<td>N785</td>
<td>S</td>
<td>DX</td>
<td>0</td>
<td>1.4154E+0</td>
<td>1.0E−6</td>
<td>NON_REGRESSION</td>
</tr>
<tr>
<td>N408</td>
<td>S</td>
<td>DX</td>
<td>100</td>
<td>2.8660E+0</td>
<td>1.0E−6</td>
<td>NON_REGRESSION</td>
</tr>
<tr>
<td>N408</td>
<td>S</td>
<td>DX</td>
<td>100</td>
<td>1.4620E+0</td>
<td>1.0E−6</td>
<td>NON_REGRESSION</td>
</tr>
<tr>
<td>N775</td>
<td>S</td>
<td>DX</td>
<td>200</td>
<td>1.5104E+0</td>
<td>1.0E−6</td>
<td>NON_REGRESSION</td>
</tr>
<tr>
<td>N775</td>
<td>S</td>
<td>DY</td>
<td>200</td>
<td>9.1092E−1</td>
<td>1.0E−6</td>
<td>NON_REGRESSION</td>
</tr>
</tbody>
</table>

4 Modeling B

4.1 Characteristics of modeling

The structure is modelled by 1496 surface meshes of type TRIA3 modelled in D_PLAN, like by 80 meshes of edge of the type SEG2 modelled in D_PLAN_ABSO as in modeling A (cf Figure 3.1)

One uses here also an auxiliary model of unit column 2D thickness generated by the operator DEFI_SOL_EQUI with the same characteristics materials in order to generate the evolutions of displacements, nodal speeds and forces by vertical level obtained for a request of wave of shearing $S$ like for a wave of pressure $P$.

The interest of this modeling is to be able to apply Dbe loadings on the side faces in the forms of plane waves with Dbe requests in speeds and displacement, or in the forms of nodal forces. Expected fields are given by tablecloths extracted the files results of the type UNITE_RESU_TRAN obtained by the calls to DEFI_SOL_EQUI. One uses for that the operator DEFI_CHAR_SOL.

One also tests the use of new options of the operator CREA_RESU: KUCV to convert the loading of plane waves into $Ka.U + Ca.V$ on the absorbing borders, CONV_CHAR to convert the loading of plane waves into evolutions second member of the type dyna_trans and CONV_RESU to convert these evolutions second member in charge of evolutions evol_char.

4.2 Results tested

The results tested are of not-regression and correspond, as for modeling A, with the computed values for each direction of request $S$ and $P$ Dbe maximum of horizontal displacement $DX$ and vertical $DY$ along the higher edge of the canyon according to the horizontal X-coordinate, with the nodes of horizontal X-coordinate 0 (center of the canyon), 100 (edge of the canyon) and 200 (flat rim of the foundation).

These results are a little different from those of modeling A but quite as close to those to the reference [bib1]. The differences being able to be explained in both cases by the very small of modelled field, is less than one diameter of canyon on both sides of this one in the horizontal direction.
5 Synthesis

The qualitative and quantitative comparison on the space paces and amplitudes along the higher edge is rather satisfactory for two modelings taking into account the low horizontal dimension of the modelled structure.

An adjustment of the parameter material LONG_CARA representative of a dimension structural feature would undoubtedly allow, by generating stiffnesses added on the elements of absorbing edge, to still improve the agreement between the analytical and calculated values.

6 References